Short-term movements and habitat use by the threatened Green-thighed Frog *Litoria brevipalmata* (Anura: Hylidae) in mid-coastal New South Wales

Francis L. Lemckert [1] and Cameron Slatyer [2,3]

[1]Research & Development Division, State Forests of New South Wales. P.O. Box 100, Beecroft. New South Wales 2119. Australia. E-mail frankl@sf.nsw.gov.au

[2]Bulahdelah District, State Forests of New South Wales.

[3]Present Address. Australian Heritage Commission. GPO Box 787, Canberra. Australian Capital Territory. 2601. Australia. E-mail Cameron.Slatyer@ea.gov.au

ABSTRACT

Miniature radio-transmitters were used to follow 13 Green-thighed Frogs for between one and five nights around their breeding ponds during the post-breeding period. Individuals were recorded to move a median distance of 5 metres per night with a maximum of 50 metres in one night. All tracked individuals remained within the available areas of forest. Frogs located at night were found in low vegetation 59% of the time, at heights between 10 cm and 150 cm above the ground. Daytime shelter sites were either under leaf litter or in thick vegetation. Cover, in the form of thick leaf litter or dense low vegetation, may be a critical requirement for the survival of the Green-thighed Frog.

Key words: *Litoria brevipalmata,* radio-tracking, movements, shelter.

Intoduction

The patterns of habitat use by anurans have been little studied due to the difficulty in tracking such relatively small and usually highly cryptic animals. After breeding, tracking studies have shown that frogs disperse into habitats surrounding the breeding site to obtain food, locate shelter or reduce predation pressure (e.g., Spieler and Linsenmair 1998; Bull and Hayes 2001). Where frogs have been tracked after breeding has taken place, individuals have moved hundreds of metres to several kilometres from their breeding sites (e.g., Sinsch 1990; Denton and Beebee 1993; Kusano *et al.* 1995; Bosman *et al.* 1996; Spieler and Linsenmair 1998). All but one published study has looked at frogs with an adult body mass greater than 30 g. The exception was Fukuyama (1991) who studied the Rhacophorid *Rhacophorus schlegelii*, which is only 15 g; this study did not look at movements, just egg laying behaviour. Smaller frogs might be expected to move smaller distances, but this has not been confirmed as such studies have been hampered by the relatively heavy mass of radio-transmitters (usually more than 1 g). It is recommended that the transmitter package be 10% or less of the study animal's mass (Richards *et al.* 1994).

The Green-thighed Frog *Litoria brevipalmata* is a small (up to 45 mm) Hylid (Tyler *et al.* 1972). The species occurs in forested areas of eastern Australia from just north of Sydney, New South Wales (NSW), to south-east Queensland (Cogger 2000). It is one of only a handful of eastern temperate Australian species that exhibit "explosive" breeding. Males congregate around large, temporary pools that form only after very heavy rainfall events (Barker *et al.* 1995; Lemckert *et al.* 1997). Calling generally lasts for only one or two nights and reproduction is highly variable. Breeding may occur just once or twice per year or not at all (Lemckert *et al.* 1997). How these frogs use the forest environment during non-breeding times has not been documented.

The Green-thighed Frog has been listed as vulnerable in the environmental legislation of both New South Wales and Queensland. Ehmann (1997) rated this frog to be at lower risk than other threatened anuran species, listing the current threats to the Green-thighed Frog as reduced water quality, habitat fragmentation and loss, and intensive forestry. Hines *et al*. (1999) noted that the Green-thighed Frog had declined in some areas and that land clearing is an ongoing threat to the species. To avoid significant impacts from disturbances and developments, conservation agencies generally require a protective, undisturbed buffer zone be left around breeding sites. This protects the water quality at the breeding site and provides at least some undisturbed vegetation that frogs can use for shelter during the non-breeding period. The width of this buffer has been determined arbitrarily and has varied greatly between sites.

We report here on a radio-tracking study of the Green-thighed Frog undertaken to record short-term movements during the immediate post-breeding period.

Study area and methods

This study was carried out around two breeding sites, both of which are ephemeral ox-bow lakes situated within 20 metres of permanently flowing streams. Site one was located approximately 100 km north of Sydney at Ourimbah in central coastal NSW (AMG 56 347300 6311400). It is a 15 m X 10 m pool that floods to a depth of approximately 1.5 m. The vegetation within a 20m radius of the breeding site is a mixed moist forest with of an overstorey including Sydney Blue Gum *Eucalyptus saligna*, Lilly Pilly *Acmena smithii*, Rough-barked Apple *Angophora floribunda* and Black Wattle *Callicoma serratifolia*. Understorey species include Cabbage Tree Palm *Livistona australis*, *Blechnum cartilagineum*, *Citriobatus pauciflorus* and *Lastreopsis* sp. The surrounding habitats include both moist hardwood forests subject to forestry activities and cleared agricultural lands (a ratio of approximately 50:50). The elevation is 60 m, mean annual rainfall 1100 mm and mean annual minimum and mean maximum temperatures 12.0°C and 23.0°C, respectively.

Site two was located 100 km further north, near Bulahdelah on the mid-north coast of NSW (AMG 56 431750 6417550). The breeding site is a 35 m X 10 m ephemeral pool that also floods to a maximum depth of around 1.5 m. The vegetation in a 1 km radius is predominantly moist hardwood forest dominated by Flooded Gum *E. grandis* and Tallowood *E. microcorys*. The understorey is dense and mesic, consisting of a mixture of at least 26 species including Blackwood *Acacia melanoxylon*, Twin-veined Hickory *A. binervata*, Native Rosella *Hibiscus heterophyllus*, Water-gum *Tristaniopsis laurina*, Grey Myrtle *Backhousia myrtifolia* and Scentless Rosewood *Synoum glandulosum*. A small area of forest 100 m south of the breeding site has been cleared for grazing. The elevation is 50 m, mean annual rainfall 1300 mm and annual mean minimum and mean maximum temperatures 13.0°C and 23.2°C, respectively. The forest around this site was subjected to intensive selective logging in the late 1960s/early 1970s and a second, more moderate logging event in 1991. The site was affected by an intense crown wildfire in 1992 that removed nearly all of the vegetation.

The frogs used in the study were captured from the vicinity of the study ponds during breeding events and then held in captivity for one to two weeks. This was done to ensure that the calling event would be finished when the frogs were released and they would immediately exhibit non-breeding movements and habitat use. Breeding frogs stay very close to the pond and move very little and frogs released while still undertaking breeding activity would have undertaken essentially no movement for that night and up to another three. Releasing frogs when still breeding would therefore have greatly reduced the already limited amount of information that could be obtained on the important non-breeding habitat use and movements.

Two hours prior to release, each frog was sexed and weighed and then fitted with a waist band and a 0.4-0.5 g single-stage radio-transmitter manufactured by Titley Electronics, Australia. The waist band was made either from a piece of cotton gauze 7 cm x 6 cm that was folded over several times to form a 7 cm x 0.5 cm strip or an elastic band cut into 7 cm x 0.5 cm strips. The bands were passed around the waist of each frog and joined together with glue to form a secure (but not overly tight) fit around the narrowest point of the waist, just anterior to the join of the legs. A radio-transmitter was then glued on to this waist band at the point where it was central on the back of the frog, allowing the 10 cm long copper aerial to trail directly behind the frog. This length of antenna provided a minimum

reception distance of 75 m. The frogs were retained for two hours following the attachment of transmitters to ensure the package was secure and then returned to the point of capture and released into some covering vegetation.

Total mass of the transmitter package was 0.65 g to 0.75 g. Only individuals of > 7 g body mass were chosen for the study (most adult females and approximately 20% of males), ensuring that the transmitter mass did not exceed the recommended level of 10% of the frog's body mass (Richards *et al.* 1994). These transmitters were expected to last a minimum of six days and so the transmitters were removed after five days if they remained attached for this long. Elastic waistbands were used to enable frogs to slip out of the package if it became tangled. However, this also allowed frogs to slip out of the belts as the waist of the frog was similar to the width at thigh level. The result was that 50% of animals slipped out of the transmitter package within 24 hours, greatly reducing the data collected, but we preferred this to frogs becoming trapped. Transmitter failure occurred once while a frog was being tracked and that individual was not recaptured.

The movements of frogs were followed over four different periods. Three frogs were tracked at Site 1 from 9-13 January 1996. At Site 2, four frogs were tracked from 2-5 February 1997, three from 17-24 March 1997, and another five frogs from 9-15 April 1999. Females are rarely located at any time and we only successfully tracked two during this study.

The frogs were relocated daily between 0900 h and 1300 h using a Regal 2000 Receiver (Titley Electronics, Australia). We recorded the resting position of the frogs at this time and marked the position to later record the distances moved each night and the distance moved from the breeding pond. Additionally, on 19 occasions, individual frogs were located after dusk (between 2000 and 0100 h) to provide information on nightly activities of frogs.

Results

Nightly distances moved for each of the 13 frogs tracked for at least one night are recorded in Table 1. The mean nightly movement for all frogs was 7.28 m (SD = 9.26; N = 36) and the median value was 5.0 m. Seven of the 36 movements (62%) were 10 m or more. The longest measured nightly movement was 50 m and no movement was recorded on four occasions. The very limited data available for females prevent a comparison between the movements of males and females.

All frogs used in the study were initially collected within 10 metres of the breeding site. Over the various tracking periods, one frog moved 55 m from the breeding site, another 40 m and all other frogs stayed within 25 m of the breeding site. The mean distance a frog was located from the breeding site was 13.2 m (SD 13.87, N = 36). The distance a frog was located from the breeding site did not appear to increase through the duration of a study period for either sex (Fig. 1). That is, frogs were not seen to be steadily moving further away from the breeding site through time.

Table 1. Mean nightly distances moved during tracking and maximum distance moved from the breeding pond for each of the tracked frogs (distances are in metres).

Site	Sex	Track nights	Mean Movement (m)	Maximum Movement (m)
Ourimbah	Male	3	5	10
Ourimbah	Female	4	3.75	10
Ourimbah	Male	1	2	2
Bulahdelah	Male	1	10	10
Bulahdelah	Male	5	5.6	20
Bulahdelah	Male	1	15	15
Bulahdelah	Male	3	2.83	6.5
Bulahdelah	Male	2	6.35	12.7
Bulahdelah	Male	3	23.3	50
Bulahdelah	Male	5	8	20
Bulahdelah	Male	5	6	10
Bulahdelah	Female	2	5	10
Bulahdelah	Male	1	5	5

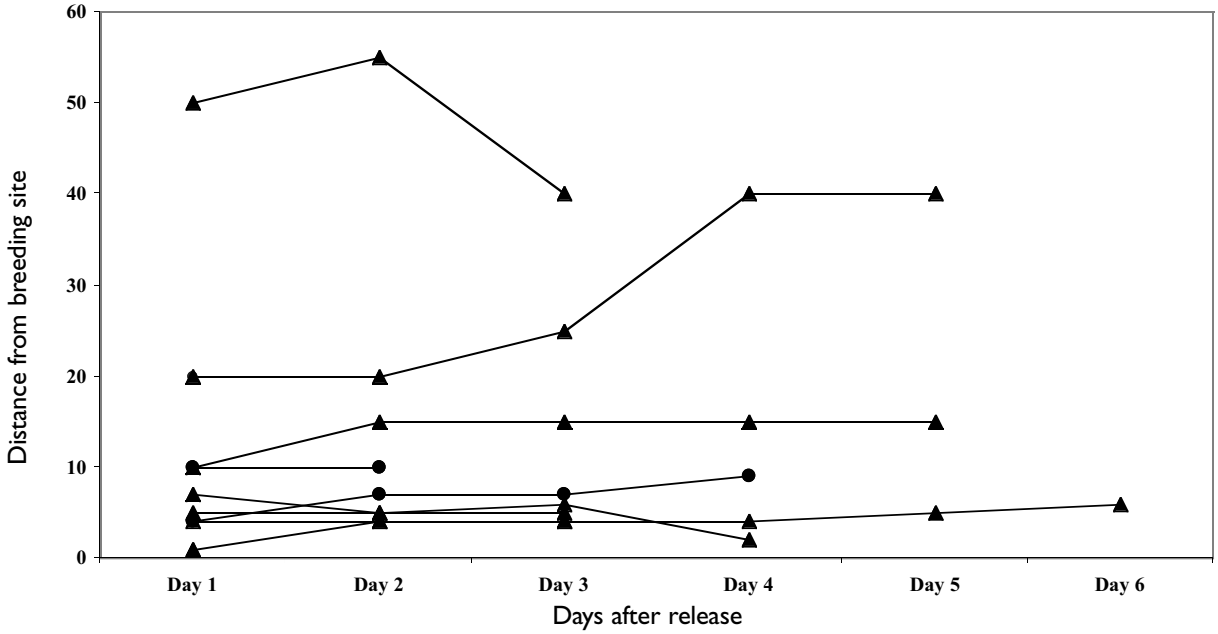

Figure 1. Consecutive daily distances from the breeding site for nine radio-tracked Green-thighed Frogs (▲ = male, ● = female)

The types of daytime shelter sites chosen over this time can be divided into two simple categories. Twenty-five of the 36 records (69%) were of frogs found under leaf litter, while the other 11 records were of frogs hidden within a dense tangle of vegetation between 10 cm and 60 cm above the ground. Nocturnal visual checks found frogs above the ground in low vegetation or on logs on 13 of 22 occasions (59%) and on the ground the rest of the time. All climbing records were of frogs between 10 cm and 150 cm of the ground. No frog was ever seen to burrow or undertake any calling/breeding activity.

One male Green-thighed Frog without a transmitter was located moving above the leaf litter at dusk when tracking at Site 1. This frog was observed for several minutes alternately jumping across the leaf litter and then resting on it. This was similar to activity to frogs being tracked at the same time.

Discussion

Previous to this study, no information had been available on the microhabitat requirements and movements of the Green-thighed Frog. This frog has rarely ever been observed at non-breeding times and its habitat requirements were unknown. It was unclear if the lack of non-breeding observations was due to excellent camouflage or due to the use of other environments where the frog could not be observed, such as high in trees. The observations confirm that Green-thighed Frogs are partly arboreal, but suggest the use of trees and low vegetation is confined to at most a few metres above the ground. Importantly, individuals appear to prefer to forage and shelter in areas with either deep leaf litter, dense low vegetation or both. This habitat provides excellent shelter opportunities that presumably protect them from both predators and desiccation and may be the critical non-breeding habitat requirement for this species. Hines *et al.* (1999) suggested that the Green-thighed Frog is not tolerant of extensive habitat modification and loss. The need for dense, low vegetation and thick leaf litter would certainly explain why this frog is not found in totally cleared and highly modified environments.

It is possible that the relatively small recorded daily movements of frogs was due to the presence of the transmitters and waist bands, but there are some indications that the impacts were not severe. The package weighed no more than the recommended 10% mass of the frogs and so should have avoided excessive depletion of energy reserves. Frogs were observed climbing up into low vegetation, including one frog that was a metre off the ground on the narrow stem of a Cabbage Tree Palm frond, indicating that transmitters did not significantly reduce flexibility or climbing ability. The male frog observed without a transmitter was located in the same area being used by frogs with transmitters and behaved in a similar way to the frogs with transmitters. This suggests that the presence of

the transmitter did not significantly alter the activity patterns of the frogs. Nevertheless, it is not possible to say with absolute confidence that the packages did not affect the movements of the frogs in some way.

Individuals in this study remained in close proximity to the breeding site (where they were released) for the duration of the tracking period. Although limited to tracking periods of less than five days, the results suggest that Green-thighed Frogs may use the vegetation surrounding the breeding sites for longer periods. Tracking of other species of frogs post-breeding has found that individuals generally leave the breeding site when breeding has been completed and move to "non-breeding" habitats, often hundreds of metres distant (e.g. Sinsch 1990; Denton and Beebee 1993; Spieler and Linsenmair 1998). Green-thighed Frogs may do the same, however this species has an unusual breeding strategy in that it breeds only after very heavy rainfall and breeding occurs on only a few nights in each year (Lemckert *et al*. 1997). Calling may last no longer than one night, leaving a very limited window of opportunity for a frog to reproduce. In such a case, individuals would be required to stay within a short distance of the breeding site or risk missing the opportunity to breed. A frog that has to move a long distance to reach a breeding site may arrive too late to reproduce. Remaining within 50 m of a breeding site would ensure that a frog commences calling or selecting a mate at the first available opportunity. Furthermore, the forests immediately adjacent to the breeding ponds used in this study offer a wide variety of shelter sites for frogs that remain close to the pond and moisture levels that minimise the risk of desiccation. Frog species that leave breeding ponds to travel some distance often do so in order to find specific protection against environmental threats such as desiccation, floods and freezing (Denton and Beebee 1993; Bosman *et al*. 1996; Spieler and Linsenmair 1998; Matthews and Pope 1999). Green-thighed Frogs at our study sites live in benign environmental conditions and so would not need to move far to find specific shelter sites. Longer periods of tracking are needed to test these ideas.

The two sites used in this study are typical of those used by the species in at least the southern half of its range (Lemckert *et al*. 1997), indicating that information collected here is likely to be typical for Green-thighed Frog populations in the region. If so, protecting the breeding sites and the surrounding vegetation would be critical for the long-term survival of any breeding population. How large such an area should be requires longer-term tracking studies to determine if frogs move further from the breeding sites as time passes.

Acknowledgements

We would like to thank Traecey Brassil, Matthew Stanton, Alison Towerton, Mark Chidel, Jason Anderson, Elizabeth Kimberley, Kevin Carter and Peter Mostyn for their assistance during this work. We also thank Dr Michael Mahony for his discussions on radio-tracking and the Green-thighed Frog. Finally we would like to thank Arthur White and Michael Murphy for their constructive and helpful comments on the manuscript and State Forests of New South Wales, Acacia Pty Ltd, Theiss Ltd and the Roads and Traffic Authority of New South Wales for their support during this work. We would like to note that Animal Care licences and NSW wildlife research permits were obtained before this study commenced.

References

Barker, J., Grigg, G. C. and Tyler, M. J. 1995. *A Field Guide to Australian Frogs*. Surrey Beatty and Sons: Chipping Norton.

Bosman, W., van Gelder, J. J. and Strijbosch, H. 1996. Hibernation sites of the toads *Bufo bufo* and *Bufo calamita* in a river floodplain. *Herpetological Journal* **6:** 83-86.

Bull, E. L., and Hayes, M. P. 2001. Post-breeding movements of Columbia Spotted Frogs (*Rana lutriventris*) in northeastern Oregon. *Western North American Naturalist* **61:** 119-123.

Cogger, H. G. 2000. *Reptiles and Amphibians of Australia*. Reed Books, Sydney.

Denton, J. S. and Beebee, T. J. C. 1993. Summer and winter refugia of Natterjacks (*Bufo calamita*) and Common Toads (*Bufo bufo*) in Britain. *Herpetological Journal* **3:** 90-94.

Ehmann, H. 1997. *Threatened Frogs of New South Wales: Habitats, Status and Conservation*. Frog and Tadpole Study Group of New South Wales, Sydney.

Fukuyama, K. 1991. Spawning behaviour and male mating tactics of a foam-nesting treefrog, *Rhacophorus schlegelii*. *Animal Behaviour* **42:** 193-199.

Hines, H., Mahony, M. and McDonald, K. 1999. An Assessment of Frog Declines in Wet Subtropical Australia. Pp. 44-63 in *Declines and Disappearances of Australian Frogs* ed. by A. Campbell. Environment Australia, Canberra.

Kusano, T., Maruyama, K. and Kaneko, S. 1995. Post-breeding dispersal of the Japanese Toad, *Bufo japonicus formosus*. *Journal of Herpetology* **29:** 633-638.

Lemckert, F. L., Mahony, M. M. and Slatyer, C. 1997. *The Green-thighed Frog in the Bulahdelah Region*. Unpublished report for the Roads and Traffic Authority of New South Wales. Research and Development Division of State Forests of NSW, Sydney.

Matthews, K. R. and Pope, K. L. 1999. A telemetric study of the movement patterns and habitat use of *Rana muscosa*, the Mountain Yellow-legged Frog, in a high-elevation basin in Kings Canyon National Park, California. *Journal of Herpetology* **33:** 615-624.

Richards, S. J., Sinsch, U. and Alford, R. A. 1994. Radio tracking. Pp. 155-158 in *Measuring and Monitoring Biological Diversity: Standard Methods for Amphibians,* edited by W. R. Heyer, M. A. Donnelly, R. W. McDiarmid, L. C. Hayek, and M. S. Foster. Smithsonian Institution Press, Washington.

Sinsch, U. 1990. Migration and orientation in anuran amphibians. *Ethology Ecology and Evolution* **2:** 65-79.

Spieler, M. and Linsenmair, K. E. 1998. Migration patterns and diurnal use of shelter in a ranid frog of a West African savannah: a telemetric study. *Amphibia: Reptilia* **19:** 43-64.

Tyler, M. J., A. A. Martin, and G. F. Watson. 1972. A new species of hylid frog from New South Wales. *Proceedings of the Linnean Society of New South Wales* **97:** 82-86.